Effect of Mycorrhizal Fungi on Leaf Litter Decomposition

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Contents

Introduction

Leaf litter decomposition releases carbon dioxide and produces nutrients for the soil. Precipitation and temperature affect the decay rate k; higher temperatures and wetter environments cause rotting to occur faster. High-quality litter, which contains more nitrogen (a limiting factor), also tends to decay faster, since the nitrogen-fixing organisms that aid in the decomposition process may favor high-N litter.

Mycorrhizal fungi have symbiosis with plants. The two main types, arbuscular mycorrhiza (AM, tends to infest inside the root) and ectomycorrhiza (ECM, tends to infest outside of root) are usually associated with different species of trees. If a tree species is mostly associated with AM, the surrounding soil is usually high in nitrogen and may have higher-quality litter. For mostly ECM trees, low nitrogen may be available in the soil, leading to lower-quality leaf litter.

There were two research questions:

1. Do AM and ECM trees vary predictably in rates of litter decomposition within and across biomes?
2. Do AM and ECM litter decomposition rates depend on differences in litter chemistry?

Independent variables:

- `Mycorrtype`: Categorical with two levels, AM and ECM
- `Biome`: Categorical with two levels, temperate and tropical
- `prec_annual`: Continuous, total annual precipitation
- `tmean_annual`: Continuous, annual mean temperature

Dependent variables:

- `Litterk`: Continuous, the rate of decay of leaf litter
- `LitterN`: Continuous, the percent of nitrogen in the leaf litter

Methods

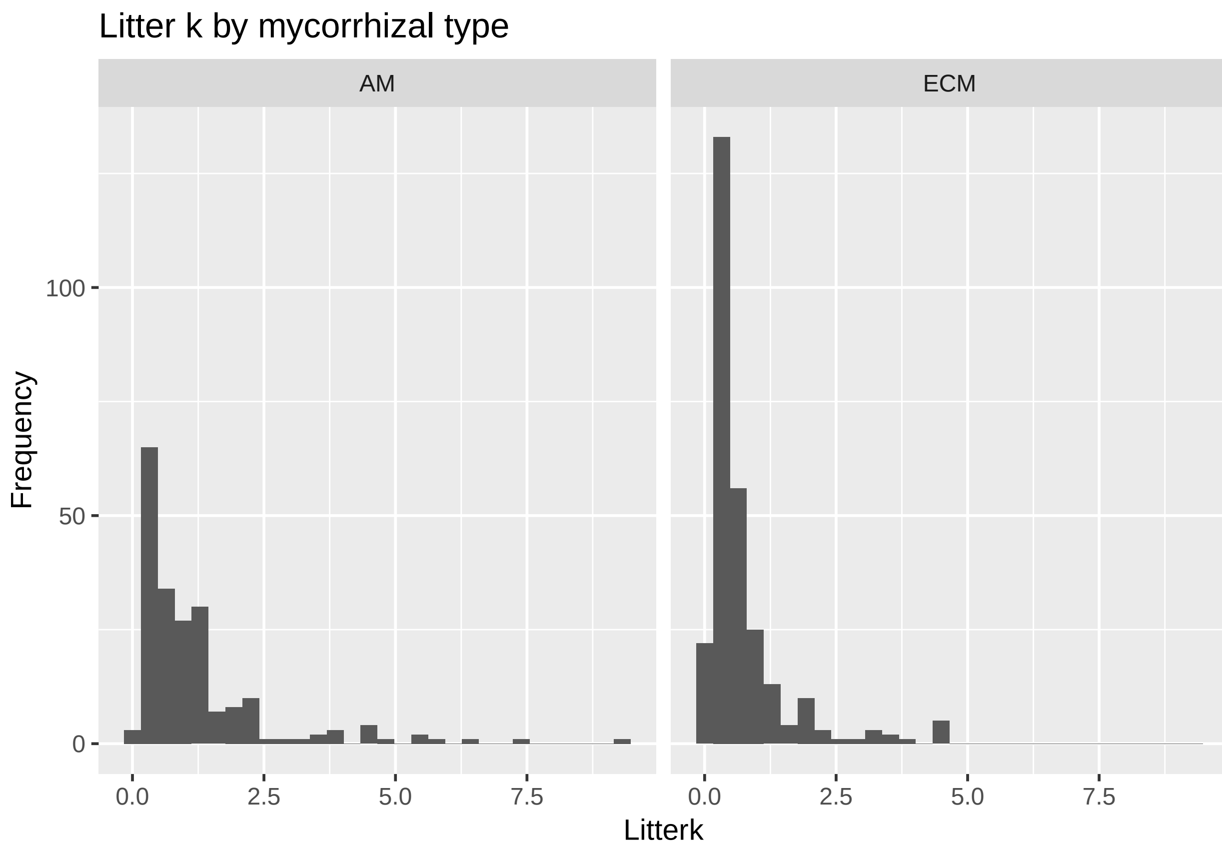
Two simple linear models were chosen for this project. During the presentation, the researcher mentioned that we were not interested in the individual trees' species, but rather their mycorrhizal association only. Thus, there is no reason to include random effects in the model. We include the interaction term for mycorrhizal type and biome.

Model 1: `Litterk ~ Mycorrtype + Biome + prec_annual + tmean_annual + Mycorrtype*Biome`

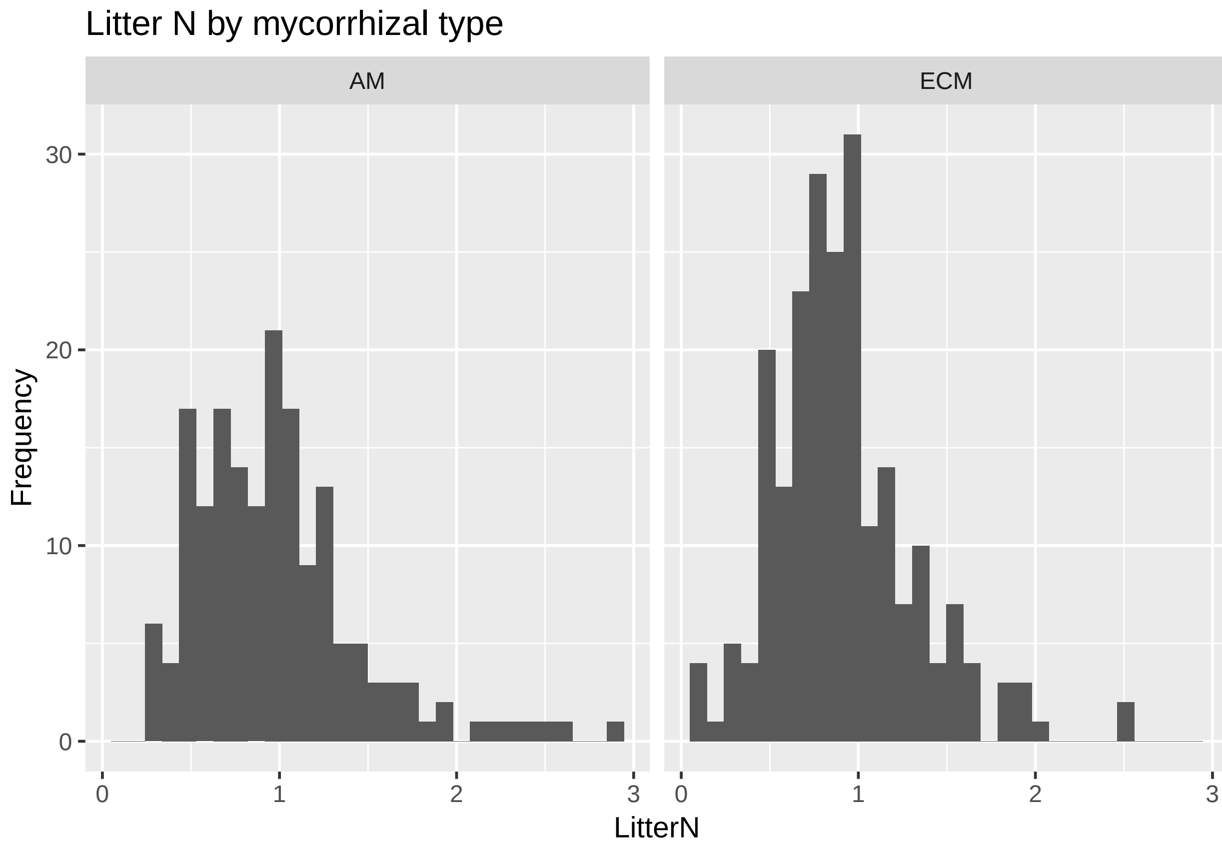
Model 2: `LitterN ~ Mycorrtype + Biome + prec_annual + tmean_annual + Mycorrtype*Biome`

The assumptions of a simple linear model are linearity, normality of residuals, homoskedasticity, and no multicollinearity.

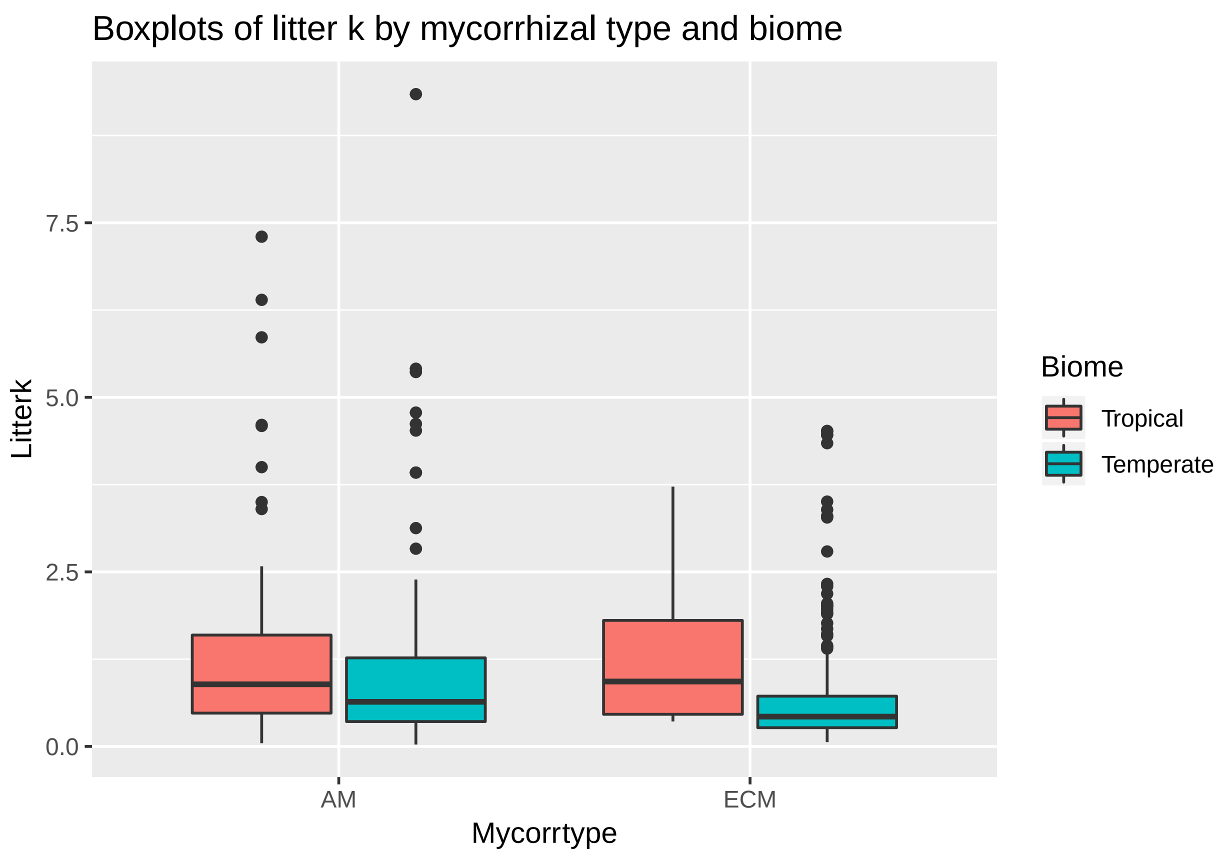
Exploratory Data Analysis



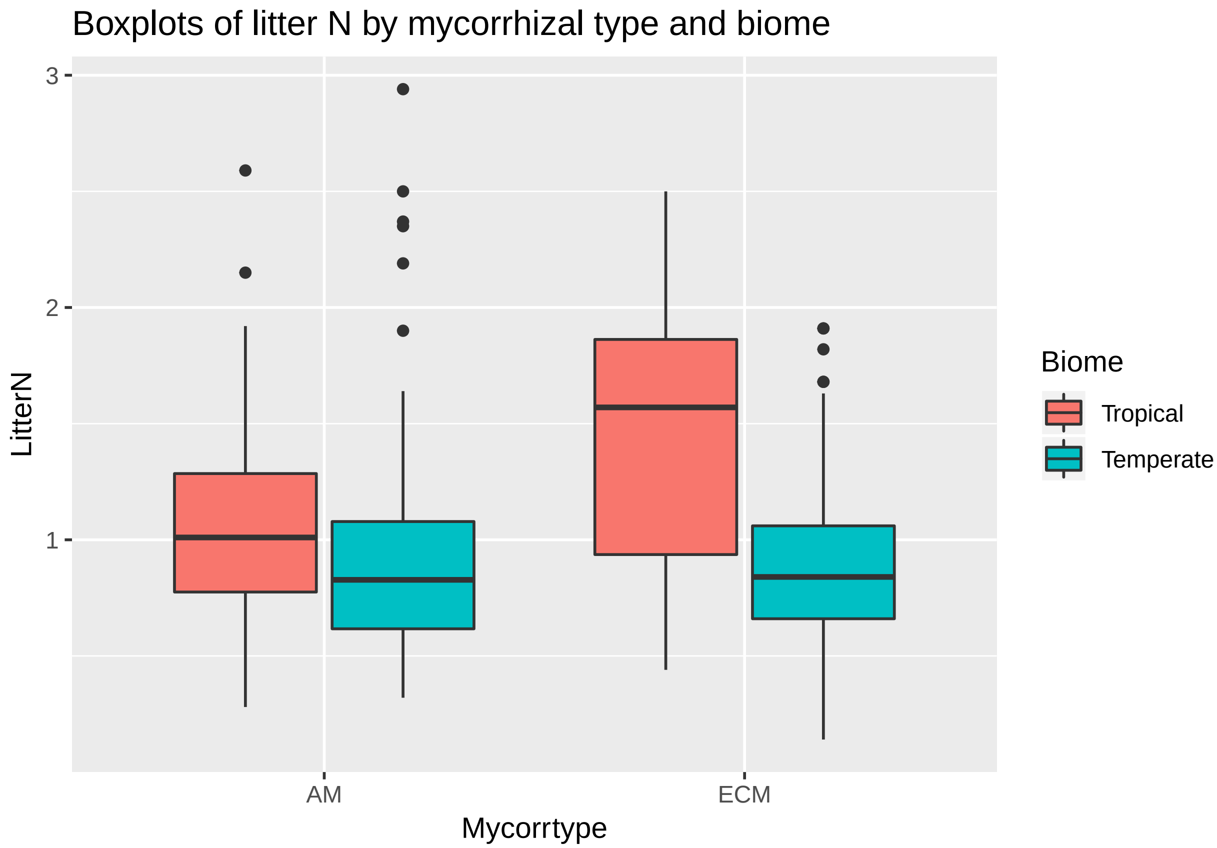
Litter k is extremely right-skewed in both AM- and ECM-associated trees.



Litter N is somewhat right-skewed in both AM- and ECM-associated trees.

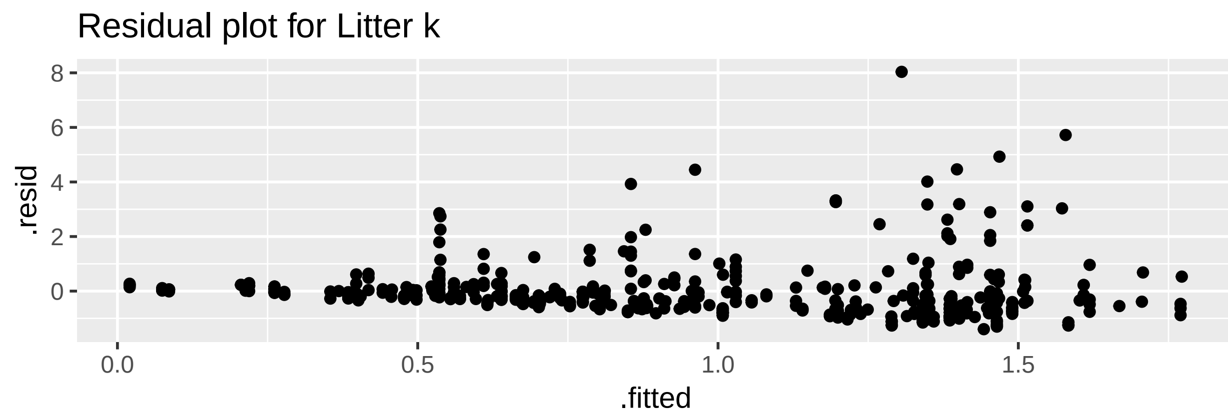


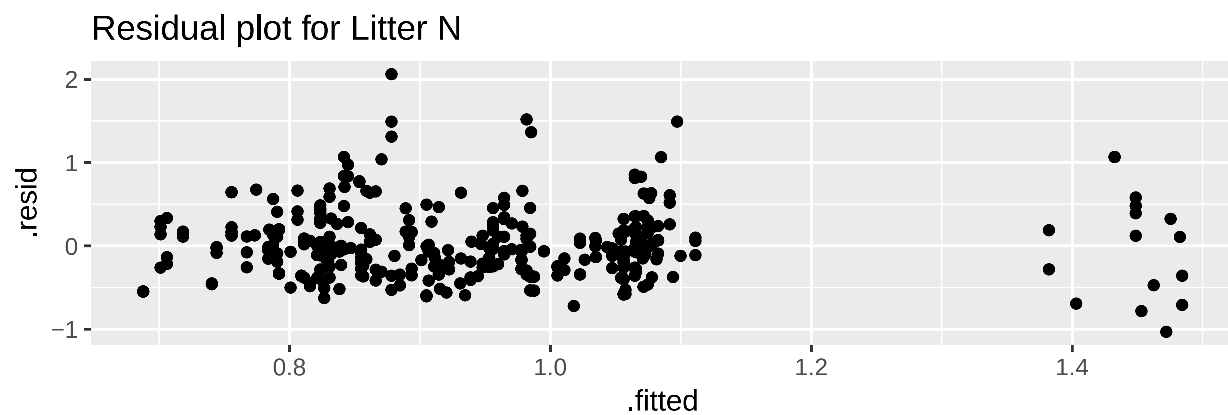
As expected, the litter decomposition rate k is higher in tropical biomes than in temperate biomes, among both AM- and ECM-associated trees. AM and ECM trees both have many outliers, which is due to the extreme right skew in `Litterk`.



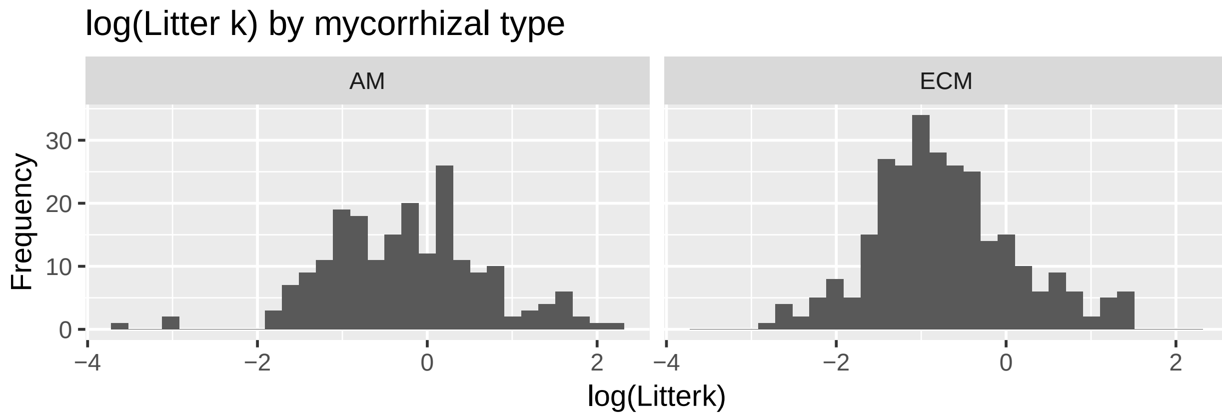
The tropical biome tends to have higher-quality leaf litter among both AM and ECM trees. There are still many outliers, again due to the right skew in `LitterN`.

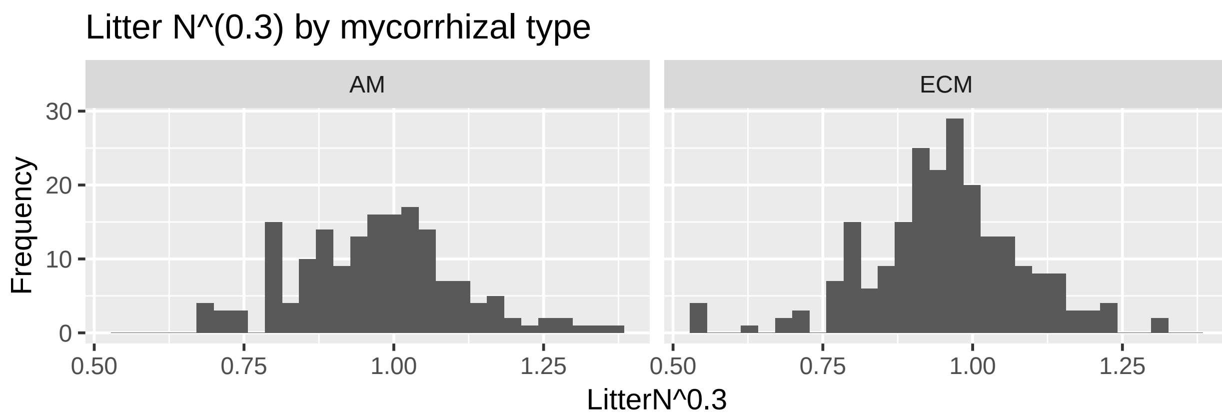
Assumption-Checking



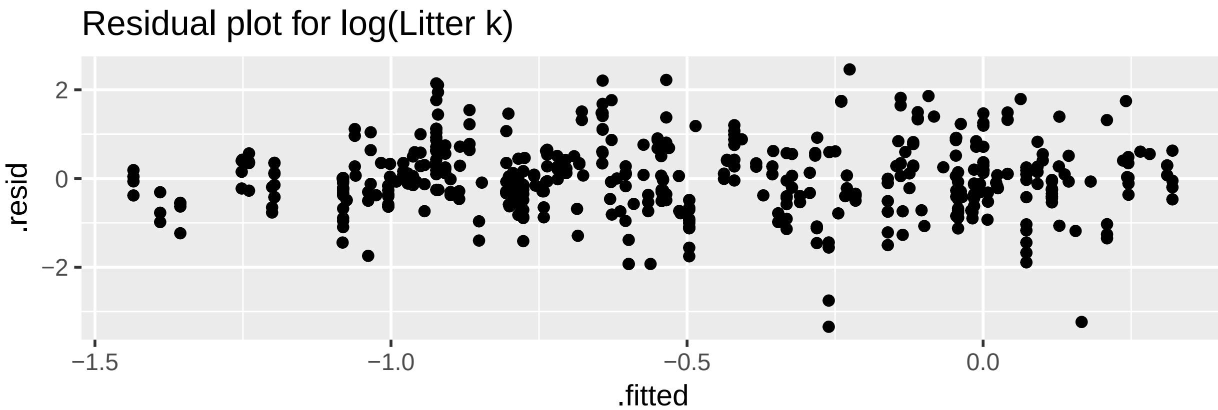


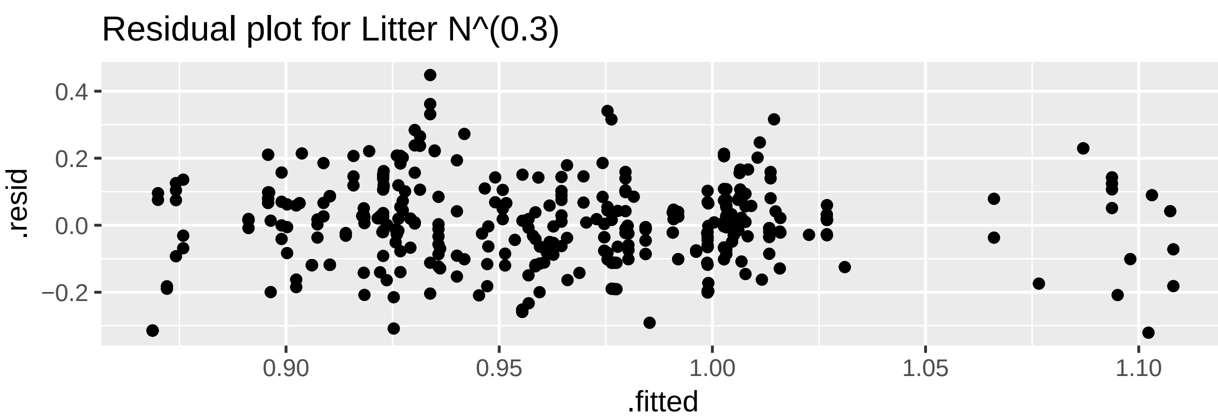
There is a clear pattern in the residuals, indicating non-linearity, and they are also not homoskedastic. We will require a transformation for `Litterk` and `Litter N`. We take the log transformation for `Litterk`. For `LitterN`, finding the optimal transformation using maximum likelihood Box-Cox transformation from the `powerTransform()` function, we get the power transformation `LitterN^(0.3)`.





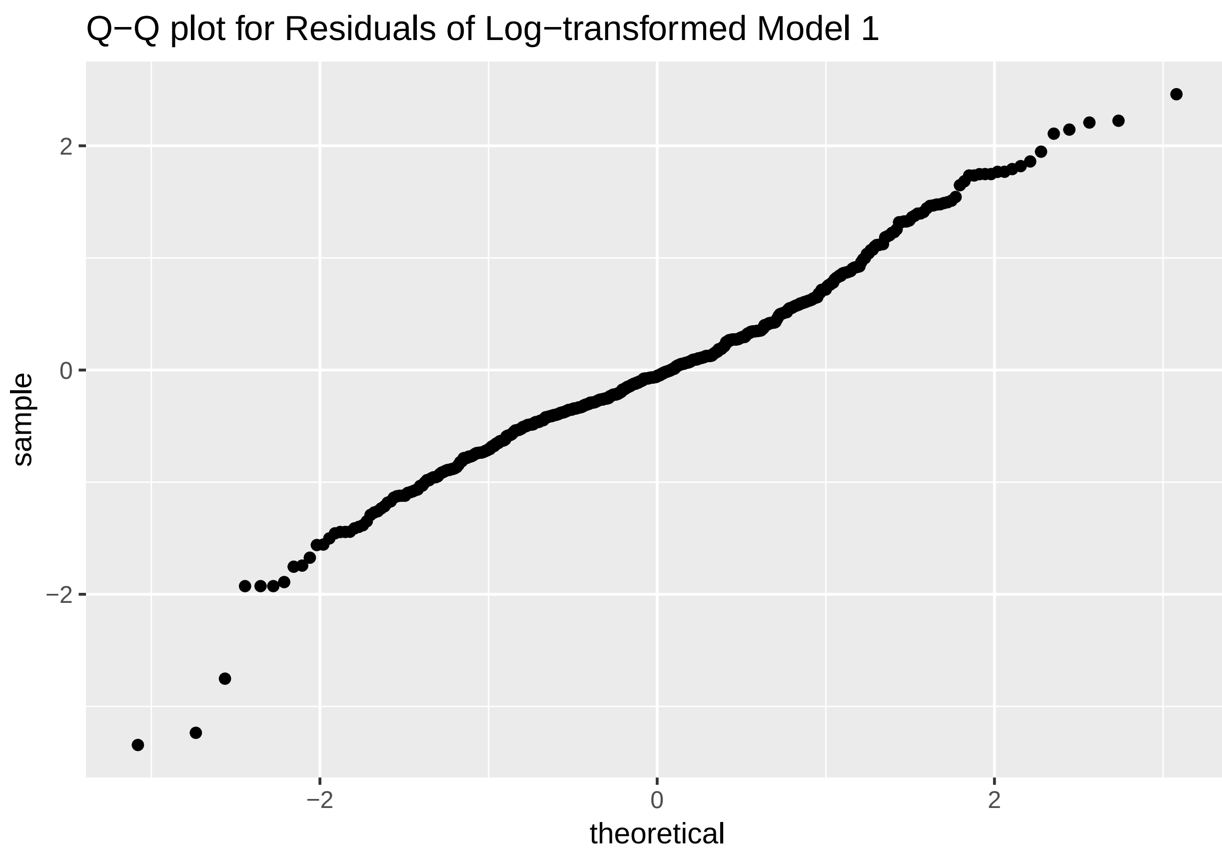
After the log and power transformations, the data is no longer heavily right-skewed. We will check the new residual plots:





The log transformation clearly improves the residual plots. There is no longer a pattern, so the relationship is linear. The residuals are also roughly homoskedastic for both models.

The Shapiro-Wilk test shows that the residuals for Model 1 are still not normally distributed, but the residuals for Model 2 are probably normal.



The Q-Q plot for Model 1 after the log transformation, however, appears mostly straight, with only a slight curviness at the lower tail. It is possible that the Shapiro-Wilk test is too sensitive to the large sample size.

Results

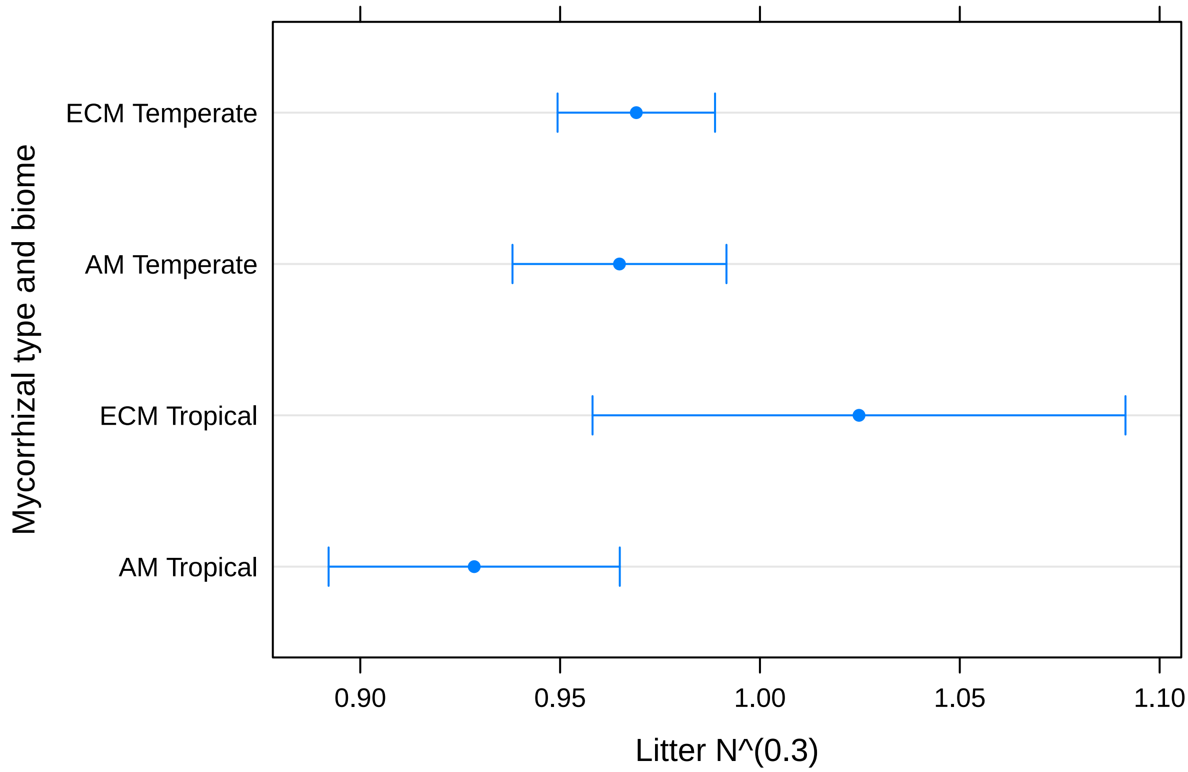
Research Question 1

Mycorrhizal type is not significant to litter decay rate, and neither is the interaction term for mycorrhizal type and biome. However, biome, annual precipitation, and mean temperature are all significant.

Thus, there is not enough evidence to suggest that a tree's mycorrhizal type can predict litter decay rate after controlling for biome, precipitation, and temperature.

Research Question 2

There is statistically significant evidence to suggest that mycorrhizal type does predict litter quality. Litter $N^{0.3}$ increases by 0.0963 when moving from AM to ECM trees ($p = 0.005$). Temperature is also significant ($p < 0.001$), but biome and precipitation are not. However, the interaction term for mycorrizhal type and biome is significant ($p = 0.015$).



From the multiple comparison, we see that the contrast in AM and ECM trees in tropical biomes is significant, but not for temperate biomes. Litter N is higher for ECM trees than for AM trees in tropical biomes, but they are about the same in temperate biomes.

Discussion

It would be helpful to clarify whether species is meant to be included as an independent variable. My group interpreted the research question to mean that the researcher did *not* intend to include `AccSpeciesName` in the model. However, if species should be an independent variable, then each species needs to have more than one or two observations.